New and noteworthy Bryophyte records from Croatia

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ABSTRACT
Within the course of a recent, extensive bryophyte survey across the whole country, eight moss taxa have been recorded for the first time in Croatia: *Conardia compacta* (Drumm. ex Müll. Hal.) H. Rob., *Cynodontium tenellum* (Schimp.) Limpr., *Dichodontium flavescens* (Dicks.) Lindb., *Fissidens fontanus* (Bach. Pyl.) Steud., *Orthotrichum philibertii* Venturi, *Rhabdoweisia crispata* (Dicks.) Lindb., *Schistidium trichodon* (Brid.) Poelt *var. trichodon* and *Tortella fasciculata* (Culm.) Culm.. In addition, new localities of five rare taxa are presented: *Didymodon tophaceus* subsp. *sicculus* (M.J. Cano, Ros, García-Zam. & J. Guerra) Jan Kučera, *Ephemerum serratum* (Hedw.) Hampe, *Mannia triandra* (Scop.) Grolle, *Oxystegus tenuirostris* (Hook. & Taylor) A.J.E. Sm. and *Sphaerocarpos michelii* Bellardi. Ecological and chorological data are provided for each of the reported taxa. Concluding, at the current state of knowledge, Croatian bryoflora includes 705 taxa, out of which 541 mosses, 162 liverworts and two hornworts.

KEY WORDS
Balkans,
chorology,
flora,
liverworts,
Mediterranean,
mosses,
rare species,
SE Europe.

RÉSUMÉ
Titre en français
intro en français

MOTS CLÉS
Balkans,
chorologie,
flore,
hépatiques,
Mediterranée,
mousses,
espèces rares,
SE Europe.

INTRODUCTION

Bryophytes of the Balkan Peninsula are still poorly known; in fact, the region of SE Europe is bryologically the least investigated area in Europe (Sabovljević 2004; Sabovljević *et al.* 2011). Croatia is a SE European country situated at the crossroads of Central Europe, the Balkans and the Mediterranean. A historical overview of bryological research in Croatia shows that the peak of research took place during the end of the 19th and the beginning of the 20th century (Alegro *et al.* 2012), followed by a large gap in research until the last decade. Pavletić (1955), in the mid-20th century, provided the most comprehensive work on the bryophytes of former Yugoslavia by gathering all historical sources and summarizing the distribution of taxa. More recently, Sabovljević (2003, 2006) and Ros *et al.* (2007, 2013) provided a checklist for the territory of Croatia, mostly based, however, on historical data. Finally, serious bryological fieldwork in Croatia continued in the 21st century, and dozens of new species were recorded for the country (Papp & Sabovljević 2009; Ellis *et al.* 2012a, b, 2014, 2015, 2016, 2017; Papp *et al.* 2013a, b, c; Alegro *et al.* 2014, 2015). However, despite considerable progress in the knowledge of the diversity and distribution of Croatian bryophytes in the last decade, a great shortage of data is still evident.

The main objective of this paper is to provide further additions to the inventory of bryophytes in Croatia.

MATERIAL AND METHODS

The field research was undertaken in the period 2011-2017 across the whole country, with a special emphasis on legally protected areas (national and nature parks) of Croatia. Collected specimens were deposited in the bryophyte collections at ZA and BP and the private collection of T. Kiebacher. The nomenclature follows Ros *et al.* (2007, 2013), except for *Didymodon tophaceus* subsp. *sicculus* (M.J. Cano, Ros, García-Zam. & J. Guerra) Jan Kučera and *Tortella fasciculata* (Culm.) Culm, which are according to Kučera *et al.* (2018) and Köckinger & Hedenäs (2017), respectively. The nomenclature of vascular plants is according to Euro+Med (2018). Geoelements are assigned mostly according to Hill & Preston (1998) and Smith (2004) and for several taxa to Düll (1984, 1992, 1999) and Dierβen (2001). Distributional data are based on Smith (2004), Frey *et al.* (2006) and Hodgetts (2015). Conservation status in SE Europe follows Sabovljević *et al.* (2004), Natcheva *et al.* (2006) and Stefănuț & Goia (2012) using abbreviations CR for critically endangered, EN for endangered and VU for vulnerable species (IUCN 2017). The revision of the genus *Ephemerum* Hampe was based on Holyoak (2010) and Ellis & Price (2015), while this of *Tortella fasciculata* (Culm.) Culm. on Köckinger & Hedenäs (2017). The delimitation of the Mediterranean area has been done according to Conservation International Biodiversity Hotspots (2018).

RESULTS AND DISCUSSION

The study of the samples collected allowed identifying eight new national records and five noteworthy records in Croatia, increasing the richness of Croatian bryophyte flora to 705 taxa, namely 541 mosses, 162 liverworts and two hornworts taxa.

The distribution of the newly recorded bryophytes in Croatia is shown in Figure 1.

New national records

Conardia compacta (Drumm. *ex* Müll. Hal.) H. Rob.

Specimen examined. — **Croatia**. Plitvice Lakes National Park, around the waterfall at Lake Okrugljak, 44°52'23.5"N, 15°35'54.4"E, 620 m a.s.l., 26.IX.2016, *leg.* and *det. B. Papp, A. Alegro & V. Šegota s.n.*, BP(BP191472).

The species was found on tufa rocks at the waterfall, not situated in the Mediterranean part of Croatia, accompanied by other bryophytes: *Barbula crocea* (Brid.) F. Weber & D. Mohr, *Brachythecium rivulare* Schimp., *Campyliadelphus elodes* (Lindb.) Kanda, *Conocephalum salebrosum* Szweyk., Buczkowska & Odrzykoski, *Cratoneuron filicinum* (Hedw.) Spruce, *Ctenidium molluscum* (Hedw.) Mitt., *Fissidens*

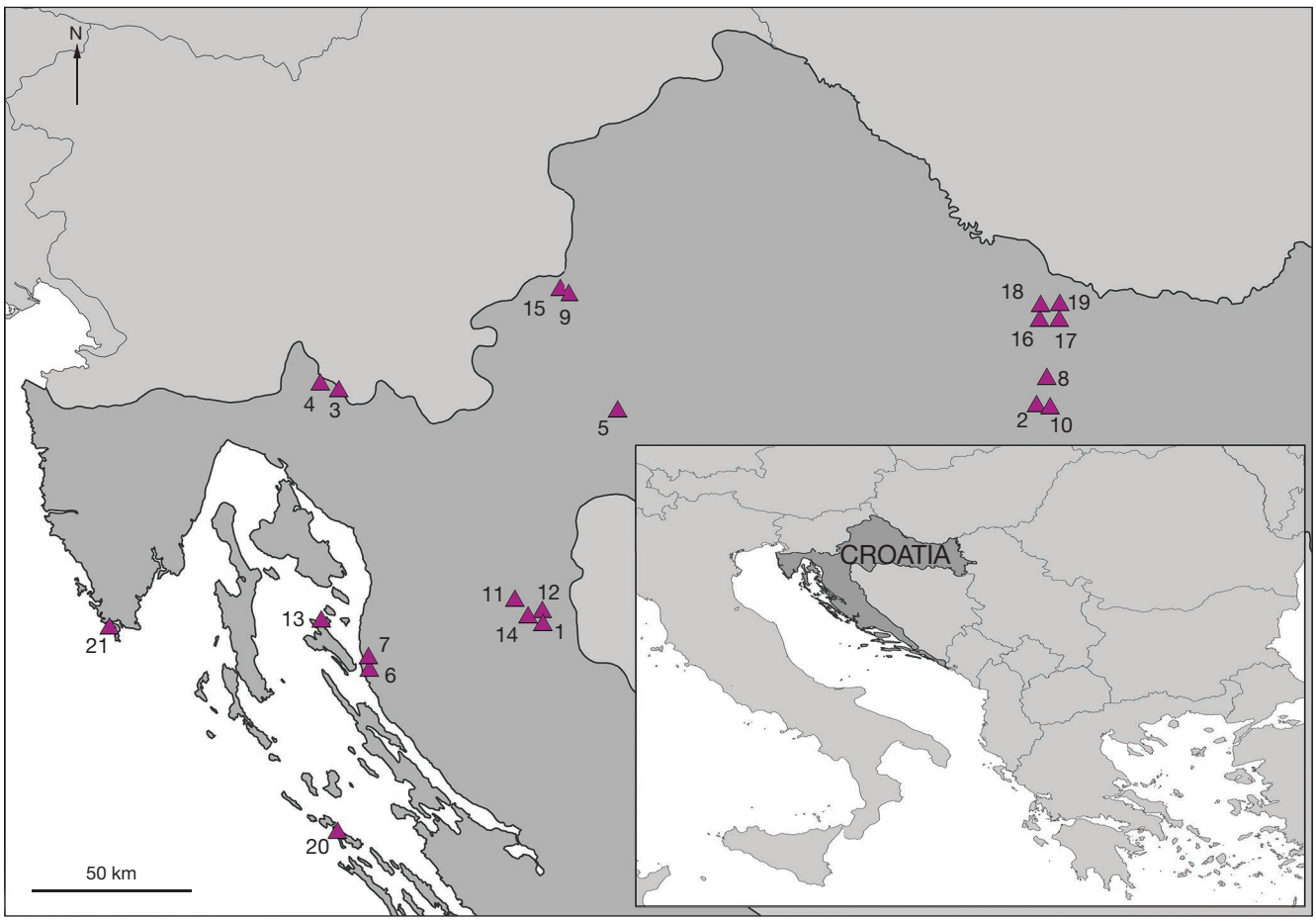

Fig. 1. — Map of Croatia indicating the collection sites of the 13 reported taxa : **1**, *Conardia compacta*; **2**, *Cynodontium tenellum*; **3**, **4**, *Dichodontium flavescens*; **5**, *Fissidens fontanus*; **6**, **7**, *Orthotrichum philibertii*; **8**, *Rhabdoweisia crispate*; **9**, *Schistidium trichodon* var. *trichodon*; **10**, **11**, **12**, *Tortella fasciculata*; **13**, *Didymodon tophaceus* subsp. *sicculus*; **14**, *Mannia triandra*; **15**, *Oxystegus tenuirostris*; **16**, **17**, **18**, **19**, *Sphaerocarpos michelii*; **20**, **21**, *Ephemerum serratum*. Insected map of the right bottom shows position of Croatia in SE Europe.

dubius P. Beauv., *Gymnostomum aeruginosum* Sm., *Hymenostylium recurvirostrum* (Hedw.) Dixon, *Mnium marginatum* (Dicks. *ex* With.) P. Beauv., *Orthothecium rufescens* (Dicks. *ex* Brid.) Schimp., *Oxyrrhynchium hians* (Hedw.) Loeske, *Palustriella commutata* (Hedw.) Ochyra and *Pellia endiviifolia* (Dicks.) Dumort. The population was small, consisting of several tiny patches. However, the plants were well developed. *Conardia compacta* is a discontinuously Circumpolar Boreal-montane species (Düll 1992; Hill & Preston 1998; Smith 2004) rather rare in SE Europe, where it is only known from Greece (Gamisans & Hébrard 1980), Romania (Ștefănuț & Goia 2012), Slovenia (Głowacki 1912) and Serbia (Sabovljević *et al.* 2008). The species is known also from neighbouring Hungary (Papp *et al.* 2010b) and Italy (Aleffi *et al.* 2008). It is considered threatened in several European countries; however, it has not been included in any Red list of SE European countries.

Cynodontium tenellum (Schimp.) Limpr.

Specimen examined. — **Croatia**. Papuk Nature Park, rocks on eastern slopes of Mališćak Peak, 45°29'14.1"N, 17°38'15.1"E, 725 m a.s.l., 13.X.2016, *leg.* and *det. A. Alegro & V. Šegota s.n.*, conf. B. Papp, BP(BP193751), ZA(ZA45474, ZA45493).

The species was found in a restricted area of several hundred square meters on steep slopes with huge siliceous outcrops and screes within an acidothermophilic *Quercus petrea* (Matt.) Liebl. forest, where it was confined to rocks, shallow crevices, cracks and fissures. The plants formed dense cushions with numerous sporophytes. This locality is not situated in the Mediterranean part of Croatia. The particular site was very rich in bryophytes, which covered the shaded parts of the rocks and forest floor in carpets (*Barbilophozia hatcheri* (A. Evans) Loeske, *Brachythecium rutabulum* (Hedw.) Schimp., *Dicranum scoparium* Hedw., *Hedwigia ciliata* (Hedw.) P. Beauv., *Hylocomium splendens* (Hedw.) Schimp., *Hypnum cupressiforme* Hedw., *Lophozia ventricosa* (Dicks.) Dumort., *Pleurozium schreberi* (Willd. *ex* Brid.) Mitt., *Pohlia nutans* (Hedw.) Lindb., *Polytrichum formosum* Hedw. *P. piliferum* Hedw., *Rhabdoweisia fugax* (Hedw.) Bruch & Schimp.). *Cynodontium tenellum* is a Circumpolar Boreoarctic Montane species (Hill & Preston 1998; Smith 2004), present in Central and Northern Europe (Smith 2004). From Balkans it is known from Bosnia and Herzegovina (Głowacki 1906), Bulgaria (Papp & Erzberger 2007), Romania (Ștefănuț & Goia 2012), Slovenia (Martinčič 2003) and Serbia (Papp & Erzberger 2005; Erzberger & Papp 2007). The species is known also from neighbouring Hungary (Erzberger & Papp 2004) and Italy (Aleffi *et al.* 2008). It is EN in Romania (Ștefănuț & Goia 2012).

Dichodontium flavescens (Dicks.) Lindb.

Specimen examined. — **Croatia**. Gorski Kotar, Kupa River, after the confluence with Čabranka River near the village Gašparci,

45°30'27"N, 14°46'28"E, 256 m a.s.l., 03.VIII.2016, *leg.* and *det. A. Alegro, V. Šegota & A. Rimac s.n.,* conf. B. Papp, BP(BP193754), ZA(ZA45475, ZA45476, ZA45477, ZA45478); Gorski Kotar, Čabranka River, at the confluence with Kupa River, 45°31'32"N, 14°41'58"E, 291 m a.s.l., 03.VIII.2016, *leg.* and *det. A. Alegro, V. Šegota & A. Rimac s.n.,* conf. B. Papp, .

In the Kupa River, the species was growing in small patches, on periodically flooded, slightly inclined and not particularly shaded limestone rocks on riverbanks. The moss was well developed, but without capsules. The accompanied species were *Brachythecium rutabulum*, *Cratoneuron filicinum*, *Fissidens crassipes* Wilson *ex* Bruch & Schimp., *Hygrohypnum luridum* (Hedw.) Jenn., *Marchantia polymorpha* L. and *Palustriella falcata* (Brid.) Hedenäs, while in the running water only *Cinclidotus riparius* (Host *ex* Brid.) Arn., *Fontinalis antipyretica* Hedw. and *Rhynchostegium riparioides* (Hedw.) Cardot were present. In the Čabranka River the species was scarce, also growing on periodically flooded limestone rocks on the riverbank, but in comparison to the previous locality the habitat was shaded by trees (*Alnus glutinosa* (L.) Gaertn. and *Salix alba* L.). The specimens were without capsules. Other species found were *Brachythecium mildeanum* (Schimp.) Schimp., *B. rivulare, Cratoneuron filicinum* and *Fissidens crassipes*. In the watercourse, bryophyte flora consisted of *Cinclidotus aquaticus* (Hedw.) Bruch & Schimp., *Fontinalis antipyretica* and *Rhynchostegium riparioides.* Both localities are not situated in the Mediterranean part of Croatia. All examined specimens had acute, sharply and irregularly toothed leaf apex, weak teeth on dorsal surface of nerve and weak papillae on lamina cells, all of which are characteristic for *D. flavescens* (Werner 2002). On the other hand, ratio of leaf length and width was 4.0-4.2, which is close to values for *D. pellucidum* (Werner 2002). Although many authors have recognized it at species level (see Werner 2002), others have treated it as a variety of *D. pellucidum* (Frey *et al.* 2006), or placed it in the synonymy with the latter (Brugués & Ruiz 2015), due to the uncertain delimitation of these taxa. *D. flavescens* is a Suboceanic Montane species (Düll 1984), present in Western, Central and Northern Europe (Hodgetts 2015). In SE Europe it is known only from Montenegro (Papp & Erzberger 2011) and Romania (Stefănuț & Goia 2012), in latter being VU (Stefănuț & Goia 2012). From neighbouring countries it is known from Italy (Aleffi *et al.* 2008).

Fissidens fontanus (Bach. Pyl.) Steud.

Specimen examined. — **Croatia**. Banovina Region, Trepča River, 45°27'41"N, 15°54'35"E, 126 m a.s.l., 18.IX.2016, *leg.* and *det. A. Rimac s.n.*, conf. A. Alegro, ZA(ZA45480, ZA45481, ZA45482).

It was frequent on megalithal substrata (> 40 cm in lenght), which formed small cascade, while the abundance was lower downstream, where the substrate was macrolithal (20-40 cm in lenght) and water was less turbulent. This locality is not situated in the Mediterranean part of Croatia. The species was associated with several other aquatic moss species such as *Cinclidotus riparius*, *Fontinalis antipyretica*, *Leptodictyum riparium* (Hedw.) Warnst., *Rhynchostegium riparioides* and a significant amount of cyanobacteria from the Oscillatoriales group, which suggests moderately polluted conditions (Erzberger 2016). *Fissidens fontanus* is an European Temperate species (Hill & Preston 1998; Smith 2004) occurring from Mediterranean to Northern Europe (Smith 2004; Frey *et al.* 2006). It is rare in SE Europe, known only from Bulgaria (Natcheva *et al.* 2006) and Romania (Stefănuț & Goia 2012), being CR in both countries (Natcheva *et al.* 2006, Stefănuț & Goia 2012). The species is known also from neighbouring Italy (Aleffi *et al.* 2008). Recently, it has been recorded in Greece, on the Lesbos Island (Blockeel & Nieuwkoop 2016).

Orthotrichum philibertii Venturi

Specimen examined. — **Croatia**. Velebit Nature Park, road connecting Adriatic Highway and hamlet Dundović-Podkuki, 44°42'40"N, 14°55'19"E, 255 m a.s.l., 20.X.2013, *leg. V. Šegota s.n.*, *det.* B. Papp, conf. T. Kiebacher, BP(BP190917), ZA(ZA45483); *Ibidem*, hamlet Matović near Šegote village, 44°43'34"N, 14°54'13"E, 135 m a.s.l., 20.X.2013, *leg. V. Šegota s.n.*, *det. B. Papp*, conf. T. Kiebacher, BP(BP190918), ZA(ZA45484).

It was found on the bark of *Acer monspessulanum* L. on the first site and on the bark of *Quercus pubescens* Willd. on the second site. Both sites were situated within small thermophilous stands of deciduous woodland dominated by *A. monspessulanum, Fraxinus ornus* L. and *Q. pubescens*, and are situated in the Mediterranean part of Croatia. The accompanying species were: *Frullania dilatata* (L.) Dumort., *Hypnum cupressiforme*, *Leptodon smithii* (Hedw.) F. Weber & D. Mohr, *Leucodon sciuroides* (Hedw.) Schwägr., *Porella platyphylla* (L.) Pfeiff. and *Tortella tortuosa* (Hedw.) Limpr. *Orthotrichum philibertii* is an Oceanic Mediterranean Montane species (Düll 1992; Dierβen 2001), known mostly from Mediterranean parts of Europe (Hodgetts 2015); however it is very rare in the Balkan Peninsula, where it was recorded solely in Greece (Lara *et al.* 2003), Romania (Stefănuț & Goia 2012) and Serbia (Papp & Sabovljević 2002). The species is known also from neighbouring Italy (Aleffi *et al.* 2008). It is CR in Romania (Stefănuț & Goia 2012) and EN in Serbia (Sabovljević *et al.* 2004).

Rhabdoweisia crispata (Dicks.) Lindb.

Specimen examined. — **Croatia**. Papuk Nature Park, siliceous outcrop above the Šumečica stream near the mountain peak Vranov vrh, 45°32'58.3"N, 17°38'38.2"E, 498 m a.s.l., 13.X.2016, *leg.* and *det. A. Alegro & V. Šegota s.n.,* conf. B. Papp, BP(BP193752), ZA(ZA45485).

It was found in an acidophilic beech forest, on the bottom of the permanently humid and shaded vertical siliceous outcrop above the stream bank. The species was growing on a tiny layer of loamy soil above the rock, forming loose patches. This locality is not situated in the Mediterranean part of Croatia. Capsules were present, but not abundant. The whole rock was rich in bryophytes, consisting of *Blepharostoma trichophyllum* (L.) Dumort., *Calypogeia fissa* (L.) Raddi, *Cephalozia bicuspidata* (L.) Dumort., *Dicranum montanum* Hedw., *Diplophyllum albicans* (L.) Dumort., *Grimmia hartmanii* Schimp., *Heterocladium heteropterum* (Brid.) Schimp., *Homalia trichomanoides* (Hedw.) Brid., *Lophocolea heterophylla* (Schrad.) Dumort., *Pellia epiphylla* (L.) Corda, *Plagiochila porelloides* (Torr. *ex* Nees) Lindenb., *Plagiothecium curvifolium* Schlieph. *ex* Limpr., *P. nemorale* (Mitt.) A. Jaeger, *Polytrichum formosum*, *Rhizomnium punctatum* (Hedw.) T.J. Kop. and *Scapania nemorea* (L.) Grolle. *Rhabdoweisia crispata* is a discontinuously Oceanic Boreal-montane species (Hill & Preston 1998; Smith 2004), present in North-western and Central Europe (Frey *et al.* 2006). It is extremely rare in SE Europe (Hodgetts 2015), recorded solely in Bulgaria (Natcheva *et al.* 2006) and Romania (Stefănuț & Goia 2012). It is known also from neighbouring Italy (Aleffi *et al.* 2008). The species is VU in Bulgaria (Natcheva *et al.* 2006).

Schistidium trichodon (Brid.) Poelt var. trichodon

Specimen examined. — **Croatia**. Samoborsko gorje Mt, road between Samobor and Slani dol, beneath the hamlet of Gradišće, 45°48'20"N, 15°40'15"E, 271 m a.s.l., 14.XI.2016, *leg.* and *det. T. Kiebacher s.n.,* conf. N. Schnyder, ZA(ZA45486).

It was found on a shaded calcareous rock at the roadside in a forest dominated by *Quercus petraea* (Matt.) Liebl. and with *Vaccinium*

myrtillus L. in the understorey. This locality is not situated in the Mediterranean part of Croatia. *Schistidium trichodon* is a Boreal Montane species (Düll 1984; Hill & Preston 1998; Smith 2004), present in Northern, Central and partially Eastern Europe (Smith 2004; Hodgetts 2015). The species is rare, and possibly under-recorded in the Balkans, where it is only known from Montenegro (Dragićević & Veljić 2006), Romania (Ștefănuț & Goia 2012) and Slovenia (Martinčič 2014). It is known also from neighbouring Italy (Aleffi *et al.* 2008).

Tortella fasciculata (Culm.) Culm.

Specimen examined. — **Croatia**. Mt Papuk, Mt Pliš, at Velika village, 45°28'15.4"N, 17°38'31.7"E, 485 m a.s.l., 07.V.2011, *leg.* and *det. B. Papp, A. Alegro & V. Šegota s.n.,* BP(BP182524), ZA(ZA45487, ZA45488); Plitvice Lakes National Park, Čorkova uvala forest reserve, shaded limestone rock, 44°54'56.8" N, 15°29'57.9" E, 950 m a.s.l., 23.VII.2013, *leg.* and *det. B. Papp s.n.,* BP(BP188161); *Ibidem*, near Lake Okrugljak, 44°52'24,0"N, 15°35'55,6"E, 635 m a.s.l., 27.IX.2016, *leg.* and *det. B. Papp, A. Alegro & V. Šegota s.n.*, BP(BP191538).

On the Mt Papuk the species was found on limestone rocks along the road, together with *Barbula convoluta* Hedw., *B. unguiculata* Hedw., *Brachytecium glaerosum* (Spruce) Schimp., *Bryoerythrophyllum recurvirostrum* (Hedw.) P.C. Chen, *Campyliadelphus chrysophyllus* (Brid.) R.S. Chopra, *Campylophyllum calcareum* (Crundw. & Nyholm) Hedenäs, *Didymodon acutus* (Brid.) K. Saito, *D. fallax* (Hedw.) R.H. Zander, *D. rigidulus* Hedw., *D. sinuosus* (Mitt.) Delonge, *D. vinealis* (Brid.) R.H. Zander, *Tortella squarrosa* (Brid.) Limpr., *Trichostomum crispulum* Bruch and *Weisia controversa* Hedw..

Both findings within Plitvice Lakes National Park were on shaded limestone rocks; however first one was within Dinaric fir-beech primeval forest in Čorkova uvala, while the second was within thermophilous vegetation near Lake Okrugljak. None of the localities are situated in the Mediterranean part of Croatia. The accompanying species in Čorkova uvala were *Alleniella complanata* (Hedw.) S. Olsson, Enroth & D. Quandt, *Apometzgeria pubescens* (Schrank) Kuwah., *Anomodon rostratus* (Hedw.) Schimp., *Brachythecium salebrosum*, *Cirriphyllum crassinervium* (Taylor) Loeske & M. Fleisch., *Ctenidium molluscum*, *Dicranum scoparium*, *Eurhynchium angustirete* (Broth.) T.J. Kop., *Fissidens dubius*, *Homomallium incurvatum*, *Hylocomium splendens*, *Isopterygiopsis pulchella* (Hedw.) Z. Iwats., *Mnium stellare* Hedw., *Rhytidiadelphus loreus* (Hedw.) Warnst. and *R. triquetrus* (Hedw.) Warnst.. The accompanying species in Okrugljak were: *Barbula crocea*, *Campyliadelphus chrysophyllus*, *Ctenidium molluscum*, *Didymodon ferrugineus* (Schimp. *ex* Besch.) M.O. Hill, *Fissidens dubius*, *Gymnostomum calcareum* Nees & Hornsch., *Preissia quadrata* (Scop.) Nees. and *Pseudoleskeella catenulata* (Brid. *ex* Schrad.) Kindb.

Integrative taxonomical approach using both molecular and morphological data (Köckinger & Hedenäs 2017), showed that in the last decades the name *Tortella bambergeri auct*. has been assigned to two independent species: *Tortella fasciculata* and *T. pseudofragilis* (Thér.) Köckinger et Hedenäs. Meanwhile, *T. bambergeri* (Schimp.) Broth. is conspecific with *T. tortuosa s.l.* Therefore, we reviewed the collections from Croatia identified as *T. bambergeri* recently recorded (Papp *et al.* 2013a, b, c). We concluded that specimens from Mt Papuk and Plitvice Lakes belong to *T. fasciculata*. All these specimens had a central stem strand and the nerve in the upper part of the leaves covered by isodiametric laminal cells. According to Köckinger & Hedenäs (2017), *T. fasciculata* is a distinctly thermophilous moss that can be characterised as a Suboceanic-sub-mediterranean floristic element; it has been recognised in Central, Northern and Western Europe so far. While in Central Europe and Sweden it usually occurs on warm and south-facing places, in Western Europe and the mountainous parts of the Mediterranean it comes on generally moister and more shaded habitats; the species inhabits calcareous rocks, but it can also be found on base-rich siliceous rocks, and usually ascends up to 1200 m. This is the first record in SE Europe.

Noteworthy records

Didymodon tophaceus subsp. ***sicculus*** (M.J. Cano, Ros, García-Zam. & J. Guerra) Jan Kučera

Specimen examined. — **Croatia**. Island of Rab, Ciganka Bay at Lopar, sandstone and loess dunes, 44°50'51.5"N, 14°43'33.5"E, 18 m a.s.l., 15.VIII.2015, *leg.* and *det. B. Papp, A. Alegro & V. Šegota s.n.*, conf. J. Kučera, BP(BP190818).

It was found on bare, sandy soil, along paths going through the *Erica arborea* L. dominated macchia, situated in the very north-east of the island of Rab, belonging to the Mediterranean part of Croatia and where sandstone and loess are present along the highly indented coastline. These habitats are extremely rare on the dominantly rocky limestone eastern Adriatic coast. The specimen was growing with *Barbula unguiculata*, *Dicranella howei* Renauld & Cardot, *Funaria hygrometrica* Hedw. and *Tortella flavovirens* (Bruch) Broth. *Didymodon tophaceus* subsp. *sicculus* is a Mediterranean-subcontinental element (Dierβen 2001) known mostly from circum-Mediterranean countries and several outlying populations (Kučera *et al.* 2018). This is the second known locality of this rare taxon in Croatia, where it was discovered on salty pastures in the easternmost parts of the country (village of Trpinja) (Papp *et al.* 2016). The taxon was recorded in other several Balkan countries: Greece (Blockeel *et al.* 2002) Montenegro (Cvetić & Sabovljević 2004), Slovenia (Blockeel *et al.* 2009), Bulgaria and Serbia (Papp *et al.* 2012) and Albania (Marka *et al.* 2013). It is known also from neighbouring Italy (Aleffi *et al.* 2003, 2008). Currently, both known Croatian populations are threatened by agriculture and tourism, in the continental and Adriatic parts of the country respectively.

Ephemerum serratum (Hedw.) Hampe

Specimen examined. — **Croatia**. Istrian Peninsula, Gornji Kamenjak, bare soil within macchia, 44°48'42"N, 13°52'45"E, 22 m a.s.l., 1.I.2016, *leg.* and *det. N. Vuković*, *V. Šegota & A. Alegro s.n.*, ZA(ZA45491); Island of Molat, Zapuntelsko Polje, shallow depression, 44°14'59"N, 14°48'28"E, 28 m a.s.l., 25.X.2015, *leg.* and *det. A. Alegro, V. Šegota, N. Vuković & Z. Sedlar s.n.* ZA(ZA47327); *Ibidem*, 8.XII.2015, *leg. Z. Sedlar s.n.*, *det.* V. Šegota & A. Alegro, ZA(ZA45490).

At Istrian Peninsula the species occurred on patches of bare soil, on an earthy pathway. The site was located in the zone of Mediterranean macchia vegetation, and the species was found along with other ephemerals: *Fossombronia caespitiformis* De Not. *ex* Rabenh. subsp. *caespitiformis*, *Oxymitra incrassata* (Brot.) Sérgio & Sim-Sim, *Riccia michelii* Raddi, *R. nigrella* DC. and *Southbya nigrella* (De Not.) Henriq. As a side note, our collected specimens had distinct untoothed leaves, thus resembling *Ephemerum stellatum* H. Philib. (cf. Frahm & Frey 2004; Smith 2004; Frey *et al.* 2006; Infante *et al.* 2010), which was synonymized with *E. serratum* (Holyoak 2010). On the island of Molat the species was found along with a rare, ephemeral vascular plant *Corrigiola litoralis* L. (Vuković *et al.* 2018), on the bare soil in a seasonally inundated area characterized by damp, shallow depressions and channels. Noteworthily, these habitats are known as "Mediterranean temporary ponds", and are very significant in the context of conservation of rare and endangered vascular plant species (Zacharias *et al.* 2007). They are facing a rapid decline worldwide (Rhazi *et al.* 2012) and are therefore listed as a priority habitat in the Habitats Directive (European Commission 2007). Specimens collected had finely papillose spores surrounded by hyaline membrane, thus resembling *Ephemerum minutissimum*

Lindb. (Risse 1996, 1997; Smith 2004; Frey *et al.* 2006). However, more recently, a new perspective on this group was provided by Ellis & Price (2015) who, as a consequence of nomenclature revision, have placed *E. minutissimum* Lindb. in synonymy with *E. serratum*. *Ephemerum serratum* is a Temperate element (Smith 2004) distributed across Europe (Hodgetts 2015). The species was previously reported in Croatia on the island of Rab (Düll 1999) and in Vrhovinsko Polje (Alegro *et al.* 2014). It is known from many SE European countries, e.g. Bulgaria, Greece, Montenegro, Serbia and Slovenia (Sabovljević *et al.* 2008) and has recently been discovered in Albania (Marka & Sabovljević 2011). The species is known also from neighbouring Hungary (Papp *et al.* 2010b) and Italy (Aleffi *et al.* 2008). It is EN in Romania (Stefănuț & Goia 2012) and VU in Serbia and Montenegro (Sabovljević *et al.* 2004).

Mannia triandra (Scop.) Grolle

Specimen examined. — **Croatia**. Plitvice Lakes National Park, shaded limestone and dolomite rocks at Lake Gradinsko Jezero, 44°52'29.3"N, 15°36'11.3"E, 611 m a.s.l., 27.IX.2016, *leg.* and *det. B. Papp, A. Alegro & V. Šegota s.n.,* BP(BP 52905/H, BP52915/H), ZA(ZA 45489).
It was found in small, earthy pits and cavities of vertical rocks, growing intermixed with *Preissia quadrata*. This locality is not situated in the Mediterranean part of Croatia. Some of the bryophyte species growing nearby were *Campylophyllum halleri* (Hedw.) M. Fleisch., *Fissidens taxifolius* Hedw., *Gymnostomum calcareum*, *Leiocolea collaris*, *Lejeunea cavifolia* (Ehrh.) Lindb., *Pseudoleskeella catenulata*, *Ptychostomum capillare* (Hedw.) Holyoak & N. Pedersen, *Ptychostomum zieri* (Hedw.) Holyoak & N. Pedersen and *Rhynchostegium murale* (Hedw.) Schimp. This is the second reliable record of the species in Croatia, after its recent discovery on Mt Žumberačka Gora (Alegro *et al.* 2015). *Mannia triandra* is a Circumpolar, Subarctic-subalpine element (Düll 1999). It is widely distributed in Central and Southern Europe with its centre of distribution in the Alps (Frey *et al.* 2006). Historically, it is known from Albania (Baumgartner 1915; Bischler *et al.* 1980), Bosnia and Herzegovina (Maly 1928), Bulgaria (Ganeva & Natcheva 2003), Macedonia (Zabijakin 1960), Montenegro (Duda 1965), Romania (Stefănuț & Goia 2012), Serbia (Sabovljević *et al.* 2004) and Slovenia (Martinčič 2011), but in Bosnia and Herzegovina, Macedonia and Slovenia there are no recent records (Sabovljević & Natcheva 2006; Ros *et al.* 2007). The species is known also from neighbouring Hungary (Németh & Papp 2011) and Italy (Aleffi *et al.* 2008). It is CR in Bulgaria (Natcheva *et al.* 2006) and VU in Romania (Stefănuț & Goia 2012). Moreover, it is listed in the Bern Convention (Council of Europe 1979), and is one of only four Croatian bryophytes listed on the Habitat Directive (European Commission 2007).

Oxystegus tenuirostris (Hook. & Taylor) A.J.E. Sm.

Specimen examined. — **Croatia**. Samoborsko gorje Hills, near the road between Samobor and Slani dol, beneath the hamlet of Gradišće, 45°48'18"N, 15°39'59"E, 300 m a.s.l., 14.XI.2016, *leg. T. Kiebacher, V. Šegota & A. Alegro s.n., det. T. Kiebacher 1295.,* conf. A. Bergamini, private collection T. Kiebacher.
It was found on rock outcrops on a steep slope within an acidophilus beech forest, in a locality not situated in the Mediterranean part of Croatia. The siliceous geological bedrock facilitates the occurrence of species such as *Bazzania tricrenata* (Wahlenb.) Lindb., *B. trilobata* (L.) Gray, *Dicranella heteromalla, Hedwigia ciliata, Sphagnum quinquefarium* (Braithw.) Warnst. and *Trichocolea tomentella* (Ehrh.) Dumort.. *Oystegus tenuirostris* is a Circumpolar Boreo-temperate species (Hill & Preston 1998; Smith 2004), scattered in montane regions throughout Europe (Frey *et al.* 2006). The species was recorded for the first time in Croatia, in Golubinjak Forest in Gorski Kotar Region (Papp *et al.* 2013a). In SE Europe it is also known from Albania (Papp *et al.* 2010a), Bulgaria (Natcheva *et al.* 2006), Greece (Düll 1995), Montenegro (Dragićević & Veljić 2006), Romania (Stefănuț & Goia 2012), Serbia (Sabovljević & Stevanović 1999) and Slovenia (Martinčič 2003). It is known also from neighbouring Hungary (Papp *et al.* 2010b) and Italy (Aleffi *et al.* 2008).

Sphaerocarpos michelii Bellardi

Specimen examined. — **Croatia**. Town of Slatina, settlement Donji Meljani, Sladojevački lug, on arable fields, 45°44'6.71"N, 17°37'35.9"E, 112 m. a.s.l., 19.III.2015, *leg.* and *det. D. Prlić s.n.*, ZA(ZA47330); *Ibidem*, 45°44'6.15"N, 17°37'16.87"E, 114 m a.s.l., 19.III.2015, *leg.* and *det. D. Prlić s.n.*, ZA(ZA47483), *Ibidem*, 45°44'6.15"N, 17°37'16.87"E, 114 m a.s.l., 23.XI.2017, ZA(ZA47484); *Ibidem*, Radlovac, along vineyard, 45°43'53.96"N, 17°36' 56.97"E, 156 m a.s.l., 5.III.2015, *leg.* and *det. D. Prlić s.n.*, ZA(ZA47331); *Ibidem*, settlement Bakić, Vrela, on arable field, 45°45'32.66"N, 17°42'4.92"E, 106 m a.s.l., X.2015, *leg.* and *det. D. Prlić s.n.*, ZA(ZA47332).
In Sladojevački lug the specimens were recorded in high abundance on loamy soil of corn and soya bean stubble fields, with *Entosthodon fascicularis* (Hedw.) Müll. Hal., *Marchantia polymorpha* subsp. *ruderalis* Bischl. & Boisselier, *Riccia glauca* L., *R. sorocarpa* Bisch. and *Tortula truncata* (Hedw.) Mitt.. In Radlovac the species was less abundant, growing along an old vineyard in the northerly exposed hilly area with *Barbula convoluta*, *B. unguiculata*, *Marchantia polymorpha* subsp. *ruderalis*, *Ptychostomum capillare* and *Tortula truncata*. In Vrela, the species was scattered on loamy and sandy soil of the tobacco stubble field with *Riccia sorocarpa* and *R. glauca*. None of the new localities are situated in the Mediterranean part of Croatia. The species was recorded only in 1923 and 1924 on the bottom of the dried Maksimir Lake in Zagreb (Horvat 1932). It is a Mediterranean-Atlantic-Macaronesian species (Hill & Preston 1998; Frey *et al.* 2006), present in Southern and partially Central Europe (Frey *et al.* 2006; Hodgetts 2015). It is very rare across the Balkan Peninsula, found only in Bulgaria (Natcheva *et al.* 2006) and Greece (Düll 1995). The species is known also from neighbouring Italy (Aleffi *et al.* 2008).

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